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Note on the departure factor in α-decay

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With 1 figure in the text

As has been shown by PERLMAN, GHIORSO and SEABORG[1], the Gamow formula for α-decay is valid only for even-even nuclides, the nuclides containing an odd neutron or proton (or both) showing prohibited decay. This prohibition is ascribed to the requirement that the odd nucleon (or nucleons) has (have) to be a component of the emitted α-particle, the time required for the assembly of the α-particle and an eventual rearrangement of the remaining nucleons causing the delayed decay.

Another interpretation, however, is also possible. If in an even-even nucleus a proton pair and a neutron pair may form an α-particle and leave the nucleus, the same should be possible in a nucleus with, say, an odd proton. As the α-decay of even-even nuclides is "allowed", proton and neutron *pairs* may rearrange themselves freely. Thus, if an α-particle leaves a nucleus containing an odd proton in the same manner, the remaining "α-hole nucleus" consists of proton and neutron pairs in their lowest energy states and the odd proton in an excited state, i.e. the previous quantum state, which it cannot leave freely. The excitation energy will be radiated as one or more γ-quanta and the α-disintegration energy is an equal amount less than the ground state to ground state disintegration energy. In fact, the "α-hole nucleus" may be expected to be so highly excited, that the remaining α-disintegration energy is insufficient to make this mode of decay observable. The α-decay will have to take place with a simultaneous partial or total de-excitation of the odd proton. The probability of this de-excitation will generally be smaller than unity, which causes the α-decay to be delayed. The "departure factor" in ref. 1 is the inverse of this probability.

If the nucleus contains an odd neutron or both an odd neutron and an odd proton the result will be the same.

If the excitation of the "α-hole nucleus" is about the same in all cases, it should be possible to classify the de-excitation processes according to their degree of forbiddenness through direct comparison of the departure factor values, in a manner similar to the classification of ft-values in β-decay[2] and the multipole order classification of γ-radiation. In Fig. 1 an attempt in this direction has been made, using the departure factors for even-odd nuclides in

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[1] I. PERLMAN, A. GHIORSO and G. T. SEABORG, Phys. Rev. *77*, 26 (1950).

[2] E. FEENBERG and G. TRIGG, Rev. Mod. Phys. *22*, 399 (1950).

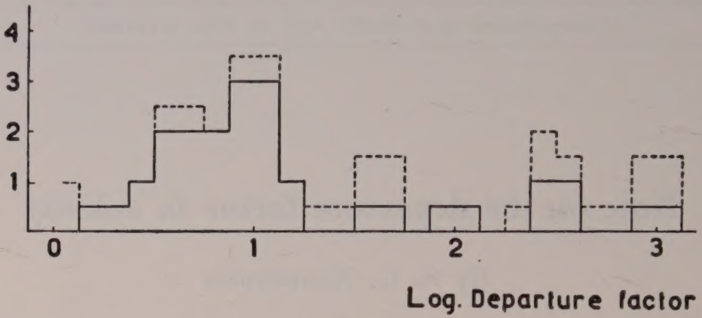

Fig. 1. Histogram of departure factor values for even-odd nuclides. The dotted line represents all values mentioned in ref. 1, Table 3; the solid line those values only which the present author considers to be the most reliable.

Table 3, ref. 1, the data on odd-even and odd-odd nuclides being less reliable, as comparison with "allowed" α-decay is indirect for these. The method for construction of the histogram is that of ref. 2, Figs. 10 and 11 and footnote 9.

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